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GEOSTATISTICAL ANALYSIS OF HIGH RESOLUTION MULTISPECTRAL IMAGERY

First Interim Report (RSSUSA - 3/1)

Dr Margaret A. Oliver and Professor Richard Webster

January 1997 to March 1996

United States Army

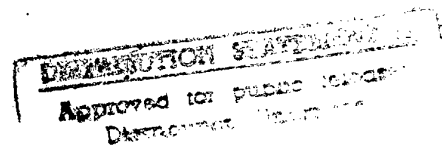
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| 14. ABSTRACT (Maximum 200 words) This is the first report of the project to apply geostatistics to high resolution remote imagery. The area chosen for analysis is part of Fort A P Hill in north-eastern Virginia. It is on the coastal plain which is heavily dissected in this area giving rise to considerable variation in relief. This report is brief as it has since been decided that the area that we started to analyse will no longer be used. This is for practical reasons. The variograms for this area showed two distinct scales of spatial variation that could be identified in the field. We shall now analyse the data for a much larger single area that we can divide into a working area and a validation one. This will enable us to test the ability of the methodology to predict ground conditions from imagery alone, and to design sampling schemes. At present we have SPOT imagery, but this will be accompanied later in the year by a high resolution imagery recorded for three seasons. The SPOT data for the area and now available and we shall start the variogram and kriging analysis of these shortly. Part of this project has been used to set up some geostatistical computing capability for TEC. Dr Oliver visited TEC for this and the report on this visit is appended to the main report. | | |
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First Report on Project to Examine SPOT Imagery in Relation to Ground Information and to to Compare this with High Resolution Imagery for the Same Area

The work for this project will be based at Fort A. P. Hill in northeastern Virginia, about 75 miles from Washington, DC. It occupies 76 000 acres of gently undulating terrain on the Atlantic Coastal Plain of the United States with an average elevation of about 50 feet. The area is intensely dissected by many small waterways, some of which drain into ponds, some of which are surrounded by wet land. Drainage is to two main basins: the Rappahannock and the James. Hence, there is a significant watershed crossing the Fort. The area is largely forested with mixed woodland, together with some open areas of shrub and grassland. The Fort is much used for training, and the effects of this on the environment are of concern. Our immediate research will not investigate this aspect specifically. However, we shall be alert to the possible effects of this on our analysis.

One of the aims of this project will be to investigate relations between SPOT imagery and the ground information, followed by an investigation using high resolution imagery to 1 m that will be available for three main periods of time, namely, winter, late spring and early summer, and late summer and early autumn. The SPOT image data are available for analysis immediately once the region to be analysed has been separated from the rest of the image.

While Dr Oliver was at TEC in November 1996, when the project was due to start, two regions were chosen for investigation. One was an area known as the Wildlife Refuge (around 9524), and the other was around Anderson Camp (9616). Our initial analysis was for the former. The variogram of the red waveband of the SPOT image was computed and modelled in preparation for the field the next day. During the field visit the landscape and vegetation of both areas were examined.

The variogram for the Wildlife Refuge showed two distinct spatial scales of variation. On walking through the forest we tried to relate the change in ground cover with the results of the variogram analysis. The shorter range of variation was about 200 m, and this structure was evident, especially in the small patches of evergreen woodland among the predominantly deciduous forest. The latter appears to represent the longer range component of the variation. There were also small open patches that would

also reflect the short-range component of the variation. There is also considerable variation in the undergrowth and the relief.

The variograms were modelled afresh when Dr Oliver returned home. The variograms of the green and red channels for the region have two distinct ranges, Figures 1 and 2. The best fitting model is a spherical model with a power function (a). In addition there are two distinct sills which has made model fitting difficult. For channel 3 a nested exponential model fitted best, Figure 3 c. For NDVI, Figure 4 c a nested exponential model also provided the best fit.

The contract for this work was finalized only at the end of March 1997, and so work could begin on the project officially only then. In the meantime it had been decided that we should work in just one area on the base; this is the larger of the two, around Anderson Camp. One reason for the change is that flights are not allowed over the Wildlife Refuge and the other that the larger area around Anderson camp will provide the scope to use a part of it for validation of any predictions. The region was chosen during Dr Oliver's second visit to A. P Hill at the end of March 1997. It is rectangle with southwest corner 970155, 940155 and northeast corner 970190, 940190. It will be divided so that we shall have access to ground information for one half, and the other will provide a basis for validating the information derived from both the SPOT image and the high resolution seasonal imagery. One aim will be to assess whether it is possible to predict ground conditions reliably from imagery alone. The ability to do this is vital where ground is held by an enemy. It is also valuable in other areas of potential danger, such as where mines have been laid, and more generally for remote regions and others areas to which access is difficult.

We have just been notified that the SPOT imagery for the region is available. Our first task will be to compute the variograms and do the kriging analysis. That will provide the basis for sampling and obtaining ground information. There is a need to submit a report at this stage, which is somewhat premature, because we need to buy the workstation on which to do all the analyses when the data arrive.

Report on Visit to Topographic Engineering Center November 1996

Margaret A. Oliver

One purpose of this visit was to discuss the results of the work carried out in phase 2 of the project. All of the work has been completed, except for the final report, which we discussed in terms of what the emphasis should be. The main purpose was to try to set up an environment for some geostatistical analysis at TEC.

Day 1 In the morning I discussed the results of the kriging analysis and geostatistical simulation with Kevin Slocum, Paul Krause and Joni Jarrett. Kevin was keen to involve Jim Moëller and Ed Bösch in the data reconstruction analysis so that we could compare the results of different approaches. A meeting with Ed was set up as he works in a different building.

In the afternoon I transferred the mapping files from England. This took some time because the files are large and the transfer slow. William Diego set up a computer user name for me so that I could work independently.

Day 2 I started to work on genstat – a statistical package that TEC has bought for geostatistical analysis. I had a trial program that I knew worked well at Rothamsted Experimental Station where the package was written. I had error messages when I ran it. They suggested that certain statements needed to be changed. I tried several changes and still got error messages. I contacted Rothamsted and they proved again that it would run there. One problem was that communication with England was very slow. I am not sure where the e-mail messages were held up.

Jim Moëller loaded the new SPOT image that we are to work on for the next project. It covers the fort at AP Hill, to the south of Fredericksburg. He and Kevin chose the two areas that we are to work on.

Ed Bösch took the small files of data from Benning which we had used for reconstructing back to the original 10 000 points using kriging and simulation. He was going to use his method of wavelets. We shall then compare the output from the three methods to see which gives the smallest error.

The method of wavelets appears to have some overlap with the kriging analysis that we used to filter the image. Jim Shine who was on the geostatistics course that I taught three years ago wanted to discuss suggestions for a PhD project. As he has a strong background in mathematics I suggested that he considers looking at the kind of overlap that exists between kriging analysis and wavelets, and how they could complement one another.

In the evening I read the genstat manual that was available (the main manual

had not been sent) and decided on some changes that I could try.

Day 3 Persevered with genstat and then discovered from Rothamsted that the version that they had been sent at TEC was 3.1 instead of 3.2. The latter is the one with the geostatistical routines. It meant that I could no longer proceed with that analysis. I tried to get some FORTRAN programs running to compute variograms, but to start with I had to use the FORTRAN compiler on the machine at Birmingham and do the analysis at TEC. This was difficult and eventually Bill Diego installed a compiler at TEC. He had to obtain some help to get it to work. In the meantime I got some of the variogram model fitting routines to run using genstat. Until they have genstat 3.2 they can use a FORTRAN program to compute the variograms. Genstat is needed for the variogram modelling. I went through the model input and output in detail with Joni Jarrett.

Day 4 I analysed the new file of data for the wildlife area of AP Hill. This is a much smaller file than that for Fort Benning. I computed the variograms and the summary statistics. In the evening I fitted the models to these variograms because we ran out of time during the day and Kevin Slocum wanted the results before going into the field the next day. All three wavebands gave similar results concerning the spatial scale in the variation.

Day 5 On the final day of my visit Kevin Slocum, Jim Moëller, Paul Krause and I went to AP Hill to look at the vegetation and relief in the two parts of the image that we shall analyse. We walked through the forest to try to relate the change in ground cover with the results of the variogram analysis. The shorter scale of variation was about 200 m and this structure was evident, especially in the small patches of evergreen woodland among the predominantly deciduous forest. The latter represents the longer scale of variation. There is also considerable variation in the undergrowth and the relief.

While in the field we decided that the vegetation would be determined from transects on coloured photographs of the area. Ground information is vital for our analysis because without this cannot interpret our results precisely.

We then visited the ITAMS office to ask whether they had the photographs of the area that we want to work in. These were ordered and should be available to TEC shortly.

I have now set up the programs for TEC to compute the variograms with the appropriate data. There is also a new file for modelling variograms that has been expanded.

Figure 1.

A.P. Hill Channel 1

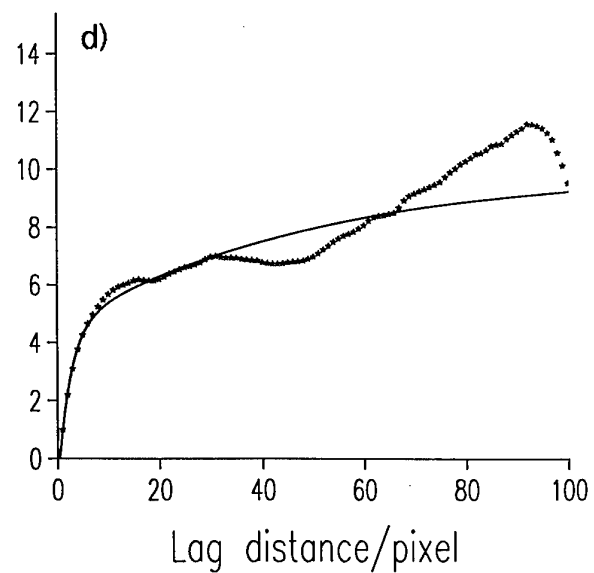
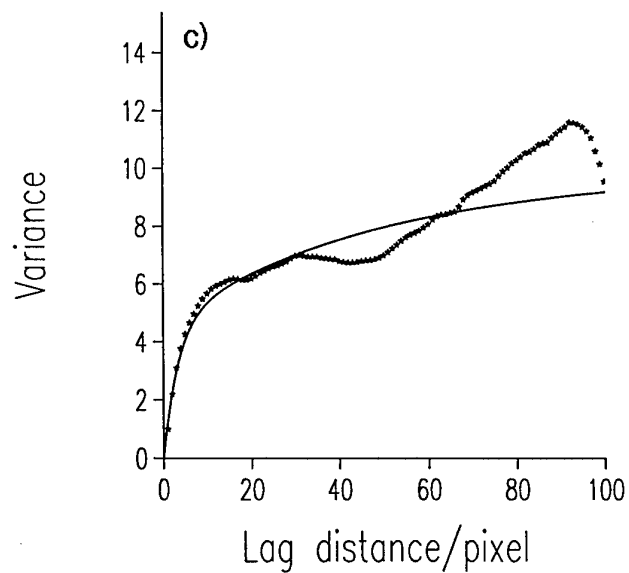
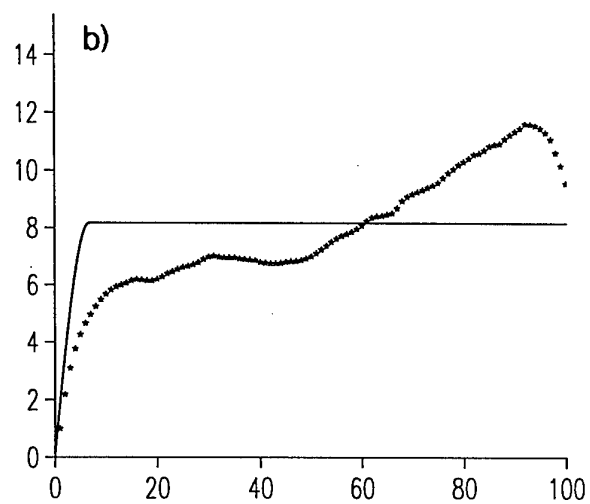
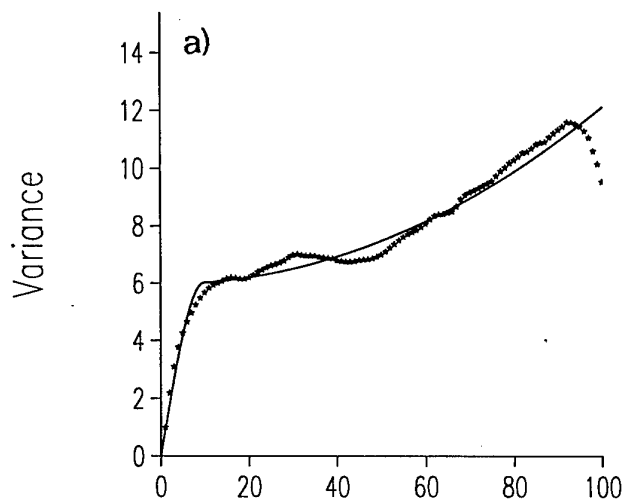


Figure 2.

A.P. Hill Channel 2

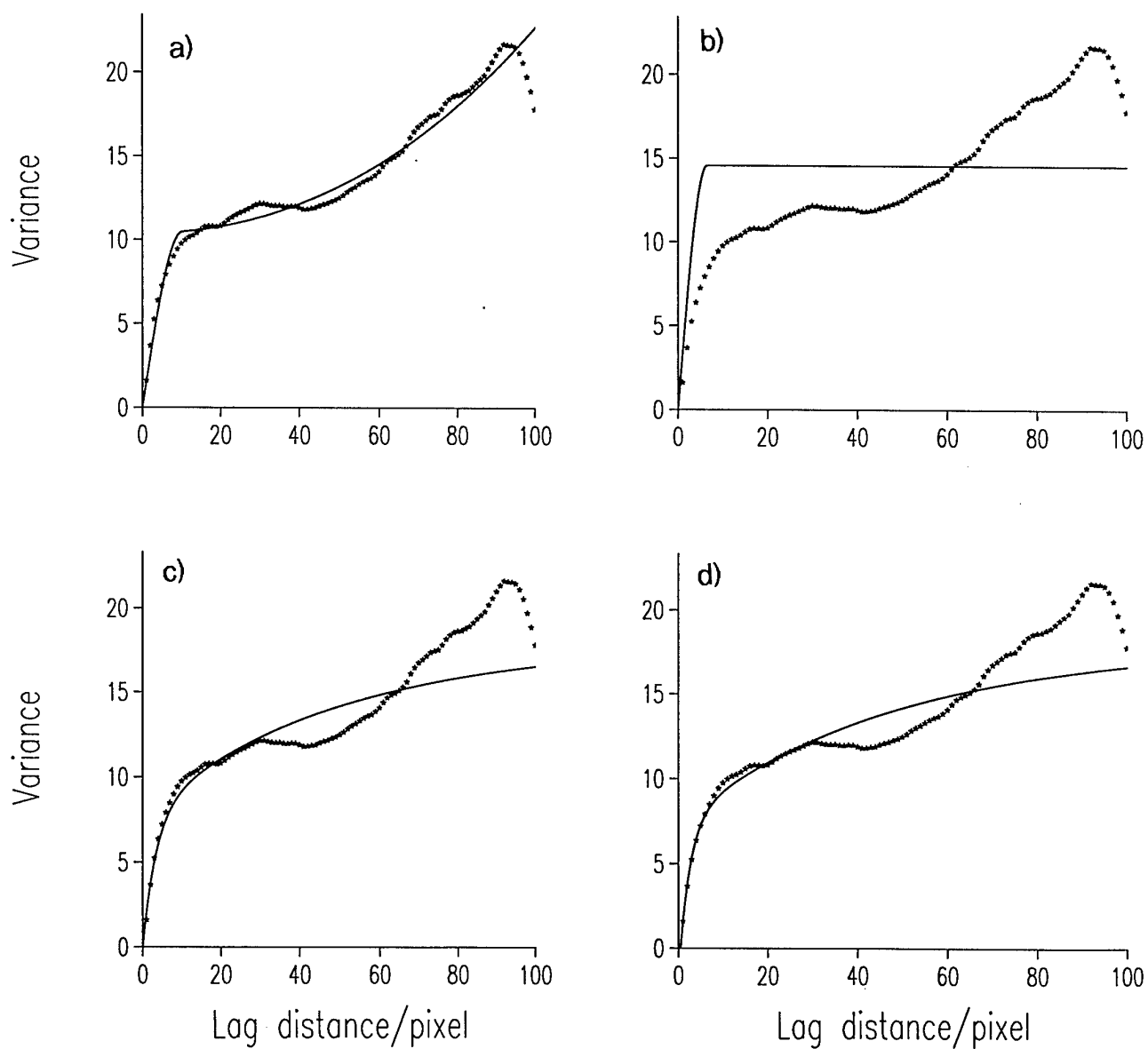


Figure 3.

A.P. Hill Channel 3

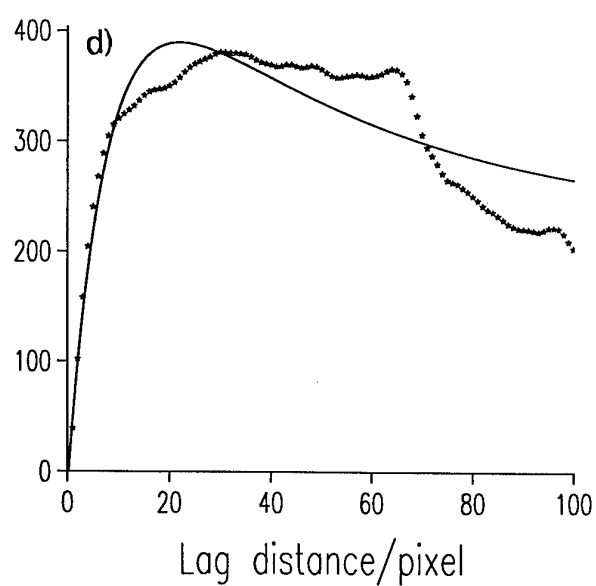
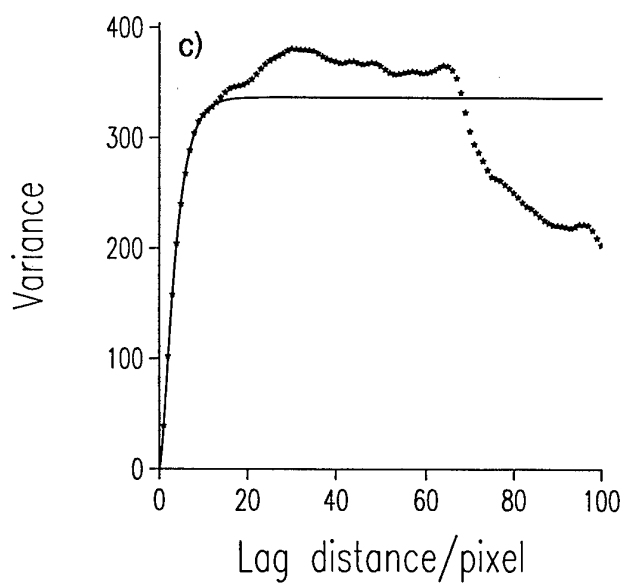
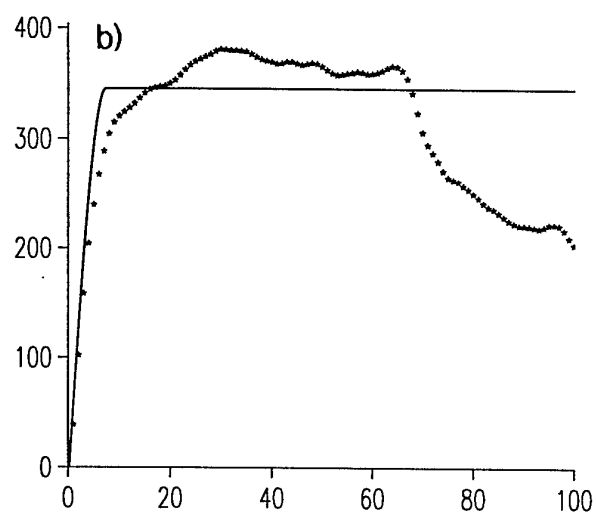
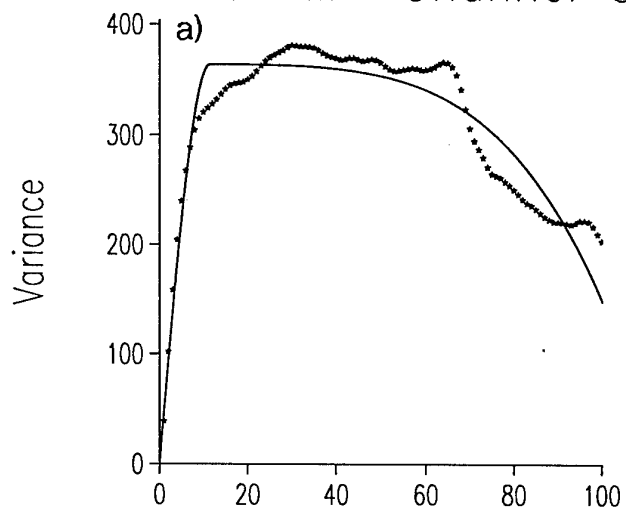


Figure 4.

